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ABSTRACT

Arguing that computer science is not a survival skill although computer literacy may be and acceptance of computers definitely is, this paper recommends that any curricular changes involved in the implementation of computer education programs should adapt the computer to the larger educational goals of the schools, and separate the computer as a learning tool from the computer as the focus of study. The importance of the computer as a tool to enhance the learning process is noted, and it is suggested that the integration of computers into the existing curriculum to improve upon less productive modes of instruction is an exciting prospect. This paper briefly surveys the current uses of computers in education and reveals the scope of contemporary problems in this area, including curricular change and teacher attitudes. Some generalizations and qualifications about applications at all grade levels are outlined, followed by a discussion of an evolutionary approach to the incorporation of computers into the K-12 curriculum. Finally, this discussion suggests some limitations and hopes for the future, along with the implications for curriculum and instruction. (DJR)

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IMPLEMENTATION OF MICROCOMPUTERS INTO THE CURRENT K-12 CURRICULUM: A CRITICAL DISCUSSION OF ISSUES

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

> "[C]omputation is in its infancy. It is hard to think about computers of the future without projecting onto them the properties and limitations of those we think we know today. And nowhere is this more true than in imagining how computers can enter the world of education."
> Seymour Papert, (1980,p. 5)

Given the intensive effort needed for a successful implementation of computer education, it would be indeed disappointing if the computers brought to a school district ended up either gathering dust at the back of the classrooms, or became the exclusive domain of a small group of students. Unfortunately this scenario is more real than hypothetical; if the checkered career of educational computing is any guide, the proper focus of our attention should not be merely the future impact of computers on our schools, but instead the correction of past misuses as well.

Even though the decision to implement a computer education program implicitly recognizes the growing importance of computers in the world at large, educational computing has yet to prove itself the coequal, at all grade levels, of the traditional skills and subjects already in the curriculum. Computer science is not a survival skill; computer literacy may be; and acceptance of computers definitely is. Therefore, any

curricular changes should adapt the computer to the larger educational goals of the schools, separating the computer as a learning tool from the computer as the focus of study.

This is not to say that computers offer nothing to education, but only to suggest that the gap between expectations and real applications is a warning signal that the schools may not yet be ready for full-blown implementation and curricular transformation. If computers have not become a major force in the participants' daily routines, it will be very difficult to implement them as a successful tool in the school setting. The realization that computer education is vital to education in general cannot be forced upon society; it must accompany the general diffusion of computer technology among common folk before it can shoulder aside traditional subject areas. Teachers, administrators, and students must be prepared, if past problems with incorporating computers into the curriculum are to be circumvented.

It is true, however, that computers offer real potential as tools to enhance the learning process. In this respect, the integration of computers into the existing curriculum has exciting prospects, especially if

the machines are used not as replacements for the teacher, but instead as an improvement upon less productive modes of instruction. Plans for computer education should not focus on the computer as the object of study, but should focus on applications using the computer either as an extension of the normal teaching technique or in classroom activities that cannot be accomplished through traditional instruction.

For present purposes, the following discussion assumes that an overall implementation is possible, within the constraints of the school structure. The reader will not fail to note the persistent theme that computers must subserve larger educational goals and not be an end in themselves; and that the key to their successful use is the adequate preparation of all involved so that the experience carries some real meaning with it.

A brief survey of the current uses of computers in education will reveal the scope of contemporary problems in this area; from this review, some generalizations and qualifications about applications at all grade levels will be outlined, followed by a discussion of an evolutionary approach to the incorporation of computers into the K-12 curriculum. Finally, this discussion will

naturally suggest some limitations and hopes for the future, along with the implications for curriculum and instruction.

Educational computing follows two main instructional modes, computer managed instruction, (CMI), and computer assisted instruction, (CAI). CMI is an instructional management system using the computer; it can assist in guiding and monitoring student progress, curriculum organization, learning diagnostics, or general instruction and direction. CMI's objective-based learning offers real potential considering the renewed call for a return to basics. Teachers who are aware of their own responsibilities and accountability in managing instruction may find this management system helpful.

CMI facilitates administrative and curricular computer-based testing. The former type serves strictly bureaucratic purposes and the teachers rarely see the results. The second type allows the teacher to determine the best course of study for the students and involves more than just the recording and comparison of test scores. The teachers actually construct a classroom management sequence that includes one or a number of subjects, but because they usually are novices at this application their lack of training makes the

establishment of this kind of program time-consuming, confusing, and frustrating. Teachers realize their deficiencies and deplore the inadequate preparation that prevents comfortable and wise use of the computer (Coburn et al., 1982; Sheingold et al., 1981).

Computer-assisted instruction uses the computer interactively. Recognized as an aid in the attainment of educational goals which already exist, CAI tends to rely upon such traditional methods of instruction as drill and practice, tutorials, demonstrations, instructional games, simulations, programming, and applications software. Some of these methods actively encourage the learner to understand and control the machine, while others prompt the learner for specific information or responses which do not require an accumulation of computer-handling skills.

As the earliest type of computer-assisted instruction and the most commonly-used format of educational computing in general, drill and practice programs rehearse basic skills previously presented in the classroom. Its developer, Patrick Suppes, claims that instead of replacing the teacher the computer extends the learning experience to give more practice (in Ellis, 1974, p. 44). Many educators view drill and

practice as an efficient, effective use of classroom time that allows the learner to advance to a new level after mastering a skill.

Drill and practice programs have their advantages. The learner controls the workpace and gets needed extra practice. These programs therefore stress stored sequences of experiences, a variety of completion schedules, independent pacing, controlled learner reinforcement, and quick evaluation and feedback. Suppes (1966) of course stressed the variety and flexibility in drill and practice apparently on the assumption that individual tailoring of curricula is a positive good that can only be enhanced by allowing a computer to assist in the effort.

But critics point out that the programs' predefined goals betoken rigidity, not flexibility. The student actually has very little control over the material, lending credence to the claim that drill and practice is merely an "electronic workbook" that confuses routine practice of old classroom skills with actual learning. The software manufacturers' ignorance of the learning process and their desire to profit from a booming software market, these critics assert, encourage a

"safety-first" attitude that relies on the methodological mainstays found in traditional textbooks. This conservative temperament can produce narrow pedagogy, boring materials, and sometimes incorrect learning (Coburn et al., 1982).

Tutorial programs suffer the same handicaps and criticisms. These programs mimic the method a teacher might use with an individual student so that the computer actually delivers the instruction and allows the student to interact. A typical instructional frame consists of a stimulus, response, and reinforcement. Some critics lump tutorial and drill and practice programs together, arguing that both of them pose the danger of inappropriate use. These programs lack enough sophistication to instruct students as well as teachers because programmed responses tend to stifle creativity, limit the users' imagination, and prevent exploration beyond the simplest dimensions of a learning concept (Coburn et al., 1982; Taylor, ed., 1980).

Another type of computer-assisted instruction, demonstrations, offers the same problems and potential as the two just discussed. The computer reduces the risk of failed experiments because it displays an actual demonstration of the learning concept developed

beforehand and caters to the specific instructional objective. Once again the outcome is predetermined so that the learner has no control over the goal.

A number of other CAI formats do overcome the drawbacks of earlier practices by providing the student with a variable degree of control over the learning situation. Simulations, for instance, place the student in a situation requiring some type of decision. This expands the possibilities of educational computing by increasing the range of educational goals. The higher-order thinking promoted by simulations faces the challenges of analysis, problem-solving, penetration beyond simple concepts, and cause-effect relationships, thereby stimulating the student's interest in the subject. The specific substantive applications of simulations programs include the examination of important economic, political, and social issues, business environments, natural and fantasy environments, and chemical and other science experiments. These programs have been especially effective in social studies, math, driver education, and business education. Simulations allow students to make risk-free mistakes, like crashing an airplane or car.

Although computer simulations provide a safe and cost-effective means of study, the immaturity of this area of computer education still results in inferior software that needs updating if it is to fulfill its promoters' mildest expectations.

Computer games develop such cognitive skills as fact-finding, making inferences, planning strategies, anticipating outcomes, and testing hypotheses. Frequently the games' unintended outcomes are equally as important as the expected ones (Coburn et al., 1982; Malone, 1980). Both simulations and games foster group collaboration because the students often must operate the machine and work out the learning concept collectively. In this way computers do not isolate students but draw them together.

Programming exercises not only employ problem-solving skills as simulations and games do, but also give the student direct access to the computer through its programming language, (usually BASIC and Logo). While BASIC's algebraic nature complicates its use with younger students or those not proficient at math, Logo's procedural structure for creating graphics relieves the user of any dependence on math.

Computer education can increase the variety of applications by drawing on other fields such as word processing, spreadsheet or numerical analysis programs, data processors, instrument monitoring devices, high-resolution graphics software, sound synthesizers, robotics, and telecommunicatons. Of course the capabilities of the respective programs and their highly specialized nature may limit their educational value.

In sum, drill and practice, tutorials, demonstrations, and most games limit the learner to preprogrammed answers, subjecting the student to the imperatives of the machine. On the other hand, programming, simulations, some games, and most applications allow the learner to help determine the exercise's outcome, provoking the student's interest in exploring further (Becker, 1982; Sheingold et al., 1981; Taylor, ed., 1980).

These illustrations of CAI suggest its potential value, but currently many educators view it skeptically, relegating it to a position among many other available instructional media used as supplementary material for conventional instruction. The cause for doubt about CAI's application to education arises from the degree to

which technology appears in the school before the staff is ready to use it. Each school seems to have one or two teachers whose enthusiasm and competence surpass the majority's ignorance of the subject (Sheingold et al., 1981). Typically the computers do not serve the curriculum's goals; instead the teachers first receive them and then must find some use for them. CAI's interactive emphasis requires trained personnel if it is to realize its potential. Therefore it will take knowledgeable, creative teachers willing to spend extra time developing the curriculum to make adequate use of the computer as an educational tool.

This review of the computer's uses in education indicates a number of advantages to educational computing. Computers open a new field of exploration to students and teachers, actively involving individuals and groups in the learning process. The flexibility of microcomputers lets the learner control the workpace, frees the teacher to give more individual attention to those who need it, and reinforces learning immediately. Simulations permit safe and cost-effective experimentation in the classroom (Coburn et al., 1982; Peterson, ed., 1984; Taylor, ed., 1980; Walker & Hess, 1984).

The successful introduction of computers into the curriculum faces some difficult problems, however. The educational establishment's ingrained resistance to innovation can derail adoption and implementation. Poor quality software plagues educators who seek new and flexible programs for their classrooms, while most teachers do not have the knowledge to enable them to detect poor quality when it appears.

A lack of funding hampers the research and development of computer materials and teacher training (Coburn et al., 1982; Peterson, ed., 1984; Taylor, ed., 1980; Walker & Hess, 1984). Lesgold & Reif (1983) reported that a conference sponsored in 1982 by the United States Department of Education concluded that computer educators will have to look to government for more funding, since business is reluctant to invest in educational projects which have yet to demonstrate any promise of profit. Certainly the growing public clamor over competency-based education in the microprocessor age will eventuate in a major effort to develop and use computer materials in education and may attract both business and government interest.

But massive investments will not make up for improper planning, mis-directed training, and a

misunderstanding of the computer's place in the curriculum. These problems have already been detected by researchers, and they must be addressed if the public's investment in computer education is to be put to wise use (Lockheed and Mandinach, 1986).

The combined results of experience and research in computers in education suggest some generalizations and qualifications concerning the implications for curriculum and instruction. Certainly the integration of computers into the curriculum must reflect the educators' assessment of the competency not only of the teachers but also of the students in handling the machines. In the elementary schools, computers must not determine the nature and direction of the curriculum; they should not be the focus of study, but instead should be incorporated as sophisticated tools which, like any other tool, are better applied to some tasks than others.

This does not imply that teachers incorporate computers without fostering in the students a sense of the machines' intrinsic worth. The use of computers in the early grades can help to overcome the kinds of misconceptions about their nature and use that later blossom into ingrained fears and prejudices about them. Thus, with proper training and preparation, the teacher

can serve the more important curricular needs while simultaneously cultivating a peripheral, acquired appreciation of the computer's unique contributions to learning.

As the course offerings expand with advancement to the higher grades, the above generalizations still apply, with the addition of electives which build upon the earlier, favorable attitudes obtained through exposure in elementary schools. That is, in the high schools educators in the traditional subject areas should still follow the orientations suggested above -- using computers in a practical fashion to subserve their larger objectives -- while more specialized course offerings permit interested students to expand their knowledge of computers to suit emerging vocational or educational needs. This philosophy of persistent, broad exposure and evolutionary, elective specialization may help to prevent the feeling among students that computers are the monopoly of a few advanced learners conversant with the arcane language and sophisticated applications they read about in the popular prints.

The basic reasoning for this argument is quite simple: if one is to speak and write in a language, accepting the need to communicate is a prerequisite. If

the future will demand more computer literacy, then a general acceptance of this innovation is the prerequisite. The gradual, evolutionary integration of computers into the schools and the curriculum accords with both the cautions stemming from past efforts and the as yet undetermined future of computers in education.

Research also suggests that computers must be used in a practical, meaningful way if they are to be used at all (Lockheed and Mandinach, 1986). This is true of all educational applications, through all grades. Students and teachers must understand that the computer is in the classroom because it helps them to teach and to learn, not because it is the "latest thing." Therefore, teachers should use computers to perform tasks which traditional forms of instruction do not accomplish as well. Furthermore, exposure to the computer should not be in disjointed modules, but over a period of time relevant to the unit being studied; this will help to avoid the kinds of problems that plague instructional television.

This use of computers stresses human control and analysis of results. The students learn that the machine serves them, and not the other way around. If the general goal of education, in any subject area, is the

development and cultivation of both independent thought and analysis and a basic understanding and appreciation of the values and culture that define and drive our society, then students must learn first and foremost that the computer is a neutral device requiring human intelligence to build it, run it, and analyze its results.

Research on computers in education has also demonstrated the desperate need for better teacher training and preparation (Wright et al., 1984; Lockheed and Mandinach, 1986). Better training is vital if teachers are to maintain interest and impress upon their students the feeling that the computer is servant and not master. Successful implementation requires that teacher be confident and relaxed with the machine and its application. Team training will help dispell the mystique surrounding computers as teachers discover their peers' bewilderments and triumphs. And in addition to imbuing in participants both an understanding of the change process and a sense of ease and control over the innovation, the consultants and planners who assist in implementation must train teachers to evaluate available software and adapt it to their own needs.

With these general observations in mind, it is possible to specify some of the curricular changes and goals that, conforming to the evolutionary approach, could help the schools to improve upon past efforts and anticipate an uncertain future with computers.

The following suggestions for the integration of computers into the K-12 curriculum are designed to illustrate the conclusions sketched above. Although it is possible to provide more detail, the objective here is to indicate how various computer applications can support existing curricular goals, foster a sense of user control and ease, enhance the learning process through practical, unique applications, promote equal access by dispelling stereotypes about the computer, and finally to stimulate the students' curiosity about the subject area and about the computer.

Some general comments applicable to all grade levels would be appropriate here. It is worth reiterating that computer use be an ongoing activity; the current tendency to schedule student use of computers for brief time periods, (say a half hour each day for one week at the beginning of each semester), hampers the accomplishment of the objectives outlined above. This concentrated exposure for a only a short time forces students to

re-learn the keyboard the next time they need to use the machine and thereby distracts them from the task at hand. In this case, it would be better to schedule a half hour per week throughout the semester rather than a half hour per day for a short time period. Certainly students should have regular access to the computer throughout any unit in which its use is desired.

Throughout the school district, at all grade levels, classes about computers should be distinct from classes in which the machines are tools used to support the curriculum. Although learning about the computer may not be interesting or necessary for all students, practical applications software used in conjunction with routine units of study holds the key to successful assimilation of computers into the schools. Also, if computers are to support the curriculum, there must be enough computers for the students to use in the above manner. Ideally, there will be enough machines in a computer lab class to support a maximum of two students per machine, and a mimimum of two computers in each classroom to support ongoing curriculum applications.

One of the most successful forms of learning is modelling. Keep in mind that if students are to model computer use, they must see it used successfully on an

ongoing basis, in a meaningful manner. Computers should be conspicuous in the school office and in classroom management methods. The production of class lists, grade records, memos to parents and among staff can all make use of the computer. Demonstrating its usefulness in both the administrative paperwork and the regular curriculum will actually show students how the computer can be used beneficially. An occasional tour of the office during which the computer's workhorse role is described will acquaint students, especially in the elementary grades, with the wider uses of computers.

Computers could serve as a link between handicapped and nonhandicapped students through the use of peripheral devices. These might include speech synthesizers to aid the deaf in learning to pronounce words properly or at least provide a readable screen for deaf/nondeaf communication. Also, braille keyboards, readers and printers, along wih optical scanners could help the blind communicate and share a task with a sighted student.

The best hope for successful implementation of computers into the schools rests in applications software, however, in the elementary grades, computer classes can be used for literacy purposes, showing students how the computer functions. This could include

aspects like disk operating system commands such as how to handle a disk, load a program, initialize disks, save and erase files, the general functioning of the computer, graphics commands, limited programming in BASIC and Logo, and simple interfacing techniques. Programming should minimize math prerequisites and emphasize more of an applied curriculum role, such as programming an adventure story incorporating the "and/or" concepts of programming into the language arts. These classes should only be offered to acquaint children with a new learning tool; participation should not be limited to an exclusive group of students whose perceived competency is the sole qualification for entry.

In the elementary classroom, the most practical use of the computer is through application software supportive of the curricular areas being studied. One example might be to use PFS File to manage an individualized spelling program in which students receive unique spelling lists, drawn from a coded, sortable master list, that are specific to the level of difficulty or to the subject matter. Students then perform tasks upon these spelling lists from a menu of language-arts-related activities stored on the same filing system. Both students and teachers could

administer tests and update the file with necessary progress reports.

Another example of using the computer in conjunction with the curriculum is to teach the binary number system to math classes through the use of a Creative Microprocessor Systems (CMS) board, using light-emitting diodes (LEDs) to indicate number patterns. The idea here is to visualize an abstract concept; the actual construction of the CMS board could even be incorporated into the lesson, so that the students secondarily exercise control over what at first glance appears to be an intimidating piece of wires and lights.

As mentioned above, the complete integration of the computer with total unit plans can give each student in the class a chance at the machine before the unit is over. For example, a three-week astronomy unit would incorporate astronomy software that all students would be able to access by the end of the third week. Obviously, this type of usage demands some sort of flexibility in the teaching methods to allow students to engage in different activities during a given time period. This may mean reorganized classroom management for some teachers, to accommodate variations in the learners' ability to accomplish computer tasks (e.g., a slow typist

or slow reader may need more time at the computer than a faster student). Peer tutoring should be expected and encouraged.

At the junior high level, the distinction between the computer as a focus of study and the computer as a learning aid should be maintained. Computer classes should put more emphasis on interfacing applications such as sound and speech synthesizers, voice recognition devices, telecommunications, robotics, computer art emphasizing photographic interfacing (such as with the digitizer), and more sophisticated graphics techniques. By this time students have the small motor skills necessary to use word processing with ease.

Occasional activities might be scheduled in which the computer itself attracts more attention but still serves a higher purpose. A practical application that junior high students would enjoy might be the production of a full-scale play. This would call for collaboration of efforts on the part of several teachers and classes of students, including the arts. Briefly, this could include a variety of interfacing techniques that the students would learn prior to the production, including electronic, computerized lighting and sound effects; design and printing of tickets, programs and poster

advertisements; and possibly a robot as a character in the play. This type of production would promote cooperation among teachers and students toward a common goal, plus provide an arena for development of their skills with the machines, and it is within the reach of a school's budget and the present state of technology. Most importantly, this type of application would merge several objectives crucial to the successful assimilation of computers in the schools: users control the machines, experience the computer's use in a variety of fields not normally associated with it (i.e. the arts), and actually see the results of their creativity.

A curriculum application which might easily be carried on in a junior high classroom would be a social studies simulation of various countries, including an analysis of economic activity which follows the production and manufacture of raw materials according to climate and geography, from extraction through marketing to consumption. Students could actually form teams and use a spreadsheet or database program to maintain and analyze relevant data. Such an application requires the use of analytical skills and higher-order intellect, and carries the added advantage of relevance to current events.

By the time students reach high school, they should be familiar with various functions of the computer, including many pieces of software, some programming techniques, and interfacing applications. More importantly, their sustained exposure to the natural applications of computers to both routine and unique learning experiences should help to demysify the machine, permitting the students to make intelligent choices about the role it will play both in their academic and personal lives.

High school classes then, should offer the opportunity to delve more deeply into matters of interest to each student. Elective classes might include advanced mathematics applications or advanced programming courses, including graphics production. Since Pascal and COBOL languages are used in some jobs, these programming languages should be offered in addition to those previously mentioned. Business applications pertinent to the high school student would be information management, data base handling, electronic mail, and message switching. Word processing would be helpful to all students in the preparation of written assignments. Ongoing supportive curriculum activities might include simulations in the areas of economics, accounting,

marketing, social studies, chemistry experiments, drivers' education or flight simulation. It is extremely important that, especially in later applications, all students be given an opportunity to explore their interests with the machines. Again, location of the computer equipment is an important issue. Centralized hardware locations can foster a sense of restrictiveness that hampers equity. Building upon the openness already encouraged through elementary and junior high, high school computer applications must reinforce the belief that computers are for everyone who wants to use them.

If the thesis of this paper and the weight of its supporting evidence seem only common sensical, it should be remembered that most previous implementations of computer education produced undesired results because they were born of expectations disconnected from the true characteristics of the education system. The most creative, useful contribution computers can make to the current curriculum is the active demonstration of their practical use as servants to broader educational objectives. This prepares the current generation for the unknown potential of the microcomputer age that is just now unfolding. Until the day arrives that an intimate knowledge of computers is as vital to social survival as

the ability to read, write, and calculate, the objective of computer education, aside from a rudimentary working knowledge of the device, should be the encouragement of interest and free choice. The practical application of computers to present educational needs will do more to inform users about the machines' social and economic significance than an entire specialized computer curriculum, difficult to implement and uncertain of real benefits, could hope to accomplish.

The status of computers in education is somewhat similar to that of the tape recorder years ago; the tape machine expanded learning opportunities along a wide spectrum of subject areas, and improved upon older methods of instruction. But our schools have never required that students learn the complicated jargon and functioning of these machines. Instead, users manipulated them as tools, became acquainted with their most basic principles, and if they so desired, explored their interests on an extra-curricular or personal basis. Tape recorders, many of them highly complex and requiring knowledge of sound equalization and acoustics, are now in more widespread use than computers -- yet no one seriously suggests making "tape recorder literacy" a requirement in the current curriculum.

This argument suggests, then, that the best way to prepare the schools for the future impact of computers is to train teachers, administrators, and students, in their practical use as enhancers of the learning process, thereby fostering a comfortable attitude about the machines that can become the foundation for creative use. An evolutionary approach to curriculum development, plus the incremental implementation advanced in the answer to the first question will help us to assess the value and uses of computers in education without imposing upon educators and students a preconceived notion of what their future relationship to computers will be. Thus, predicting the future impact of computers on the schools is more a fanciful than a productive activity; the legacy of past implementations has uncovered problems that need our attention now, if computers are ever to claim a successful educational role in the first place.

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